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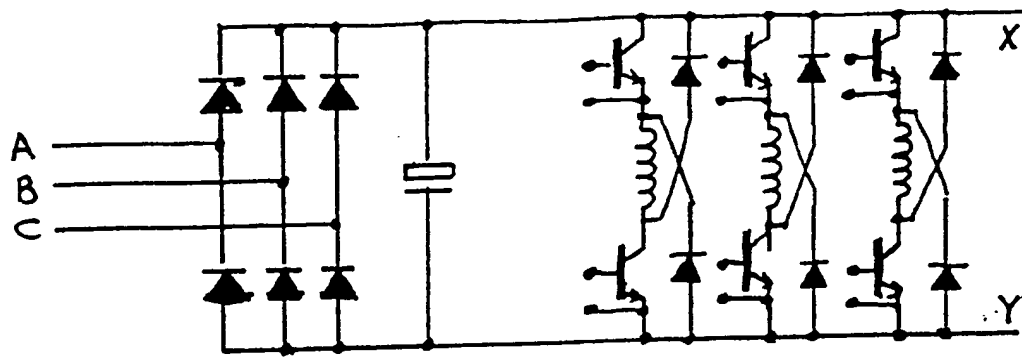


FIG 1

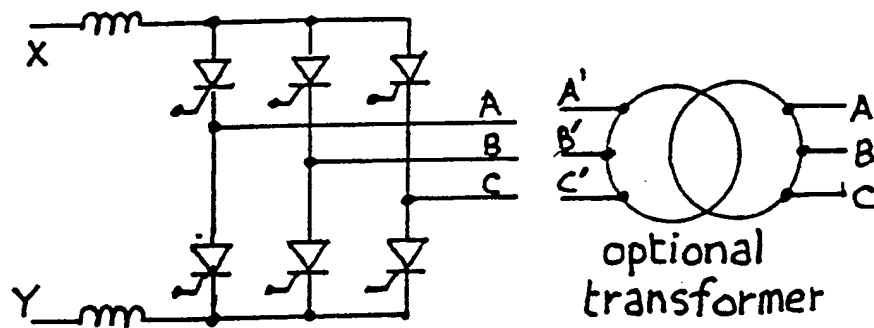


FIG 2

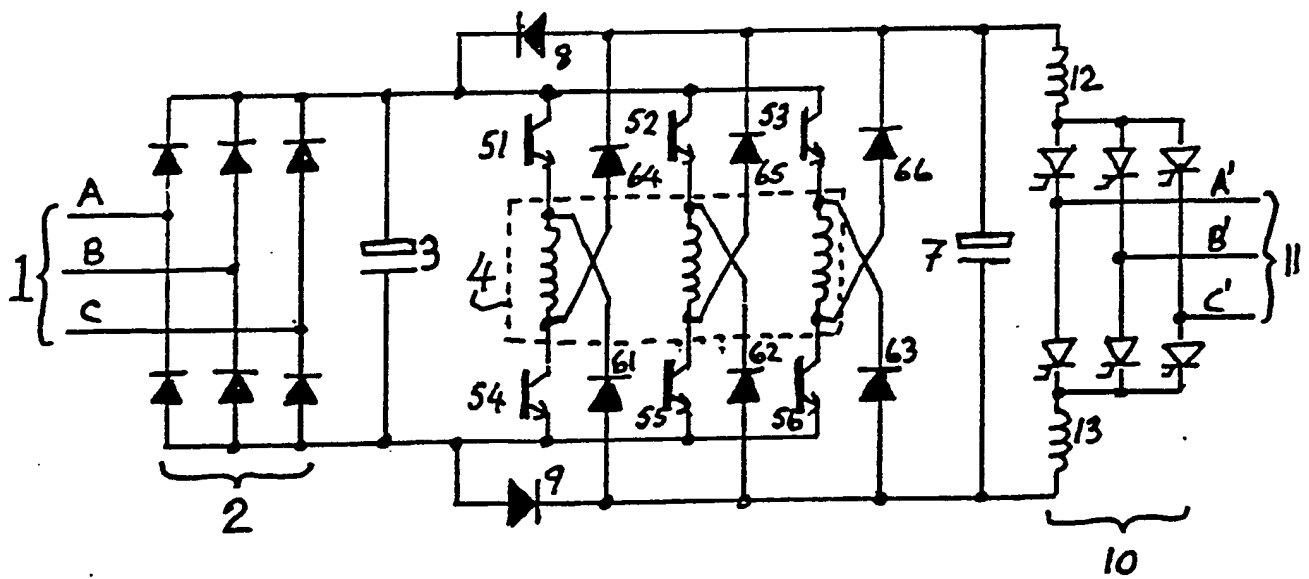


FIG 3

DESCRIPTION

Switched reluctance (SR) drives designed for motoring only conditions, and drawing power from an ac source of voltage, require a rectifier circuit, usually a single phase or three phase bridge circuit comprising four or six diodes to create an intermediate direct voltage source. The direct output voltage from the bridge rectifier is smoothed by a dc link capacitor across which the SR power converter powering the SR motor is connected. The SR power converter includes active power semiconductor switches which sequentially connect and disconnect the intermediate direct voltage source, smoothed by the dc link capacitor, to the SR motor winding(s), and diodes through which winding currents still present when the active switches are turned off are returned to the dc link capacitor.

When the SR motor is operating as a motor, power flows from the ac source voltage via the rectifier and SR power converter to the SR motor. If, however, the SR motor is required to produce a braking torque, ie to generate, power flows from the SR motor via the SR converter to the dc link capacitor. Since the diode rectifier does not permit power to be returned to the ac source of voltage, the generated power charges the dc link capacitor to a higher voltage, placing additional voltage stresses on the power conversion system. Only a limited amount of regenerated energy can be stored safely in the dc link capacitor.

If an SR motor drive is required to operate in the generating mode where the regenerated energy is greater than can be safely stored in the dc link capacitor, a well known means of absorbing the regenerated power is to dissipate it in a dynamic braking resistor which is connected in parallel with the dc link capacitor by a semiconductor power switch which is activated only when the dc link voltage exceeds a threshold value approximately equal to the peak value of the ac voltage source. Another well known means of absorbing the regenerated power is to interpose a thyristor bridge inverter circuit including one or more inductors connected between its dc terminals and those of the dc link capacitor, with its ac terminals connected either directly, or via a transformer, to the ac voltage source. If no transformer is used, problems can arise associated

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with currents circulating between the terminals of the ac voltage source via one or more diodes of the rectifier and one or more thyristors of the inverter. If a transformer is used it represents a cost and weight disadvantage.

The objects of the present invention are to avoid the circulating current problems and the penalties associated with the transformer.

According to the present invention, a thyristor bridge inverter is so connected to the SR converter and to the ac source of voltage, without requiring a transformer, that no circulating currents between the diode bridge rectifier and the inverter are possible. In addition to the thyristor inverter, the invention provides a second capacitor to which diodes of the SR inverter return energy. The said second capacitor has its positive terminal connected to the positive terminal of the dc link capacitor via a diode whose conducting direction is chosen to convey current towards the positive terminal of the dc link capacitor, and has its negative terminal connected to the negative terminal of the dc link capacitor via a second diode whose conducting direction is chosen to convey current away from the negative terminal of the dc link capacitor.

When the SR drive is operating as a motor, the two said diodes conduct which effectively connect in parallel the dc link capacitor and the said second capacitor. The thyristor bridge inverter is inhibited and inoperative during motoring conditions.

When regenerative operation is called for, the thyristor bridge inverter is activated, drawing current from the said second capacitor, and partially discharging it until the said two diodes become non-conducting, thus removing the possibility of circulating currents. The inverter is then controlled, according to known methods, to maintain the voltage across the second capacitor at a value which avoids conduction of the said two diodes, while returning regenerated power via the said second capacitor and thyristor inverter to the ac source of voltage.

The invention is described by way of example with reference to the following figures in which Fig 1 shows prior art for a non-regenerative SR drive for a 3-phase motor drawing power from a 3-phase ac voltage source.

Fig 2 shows a thyristor bridge which can be added to an SR drive according to prior art whereby regeneration is made possible, but which either features circulating current problems between the diode rectifier and the thyristor inverter or involves the positioning of a transformer between the inverter and the ac source of voltage. The terminals XY of Fig 2 attach to terminals XY of Fig 1, and terminals A B C of Fig 2 attached to terminals A B C of Fig 1, or to terminals A' B' C' of the transformer whose output terminals A B C are connected to the terminals A, B, C of Fig 1.

Fig 3 shows an example of the invention applied to a 3-phase motor drawing motoring power from a 3-phase ac source of voltage and returning regenerated power to the said source via a thyristor inverter.

In Fig 3, the ac source of voltage is shown at 1 and 11 with connections made either directly or via ac reactors between A and A', B and B' and C and C'. The diode rectifier is shown at 2, the dc link capacitor at 3, the SR motor windings at 4, the active semiconductor switches, transistors in this example at 51-56, and diodes for carrying motor winding current when one or both transistors of any winding are non-conducting at 61-66. The second capacitor into which the diodes 61-66 feed energy is shown at 7, the voltage of which can only exceed that of capacitor 3 by the small voltage necessary to make diodes 8 and 9 conduct. The inductor windings 12, 13 which can be on the same or separate iron cores, provide for the instantaneous differences in potential between the capacitor 7 and the ac lines A' B' or B' C' or C' A' depending on which thyristors of the inverter bridge 10 are conducting.

Thyristor firing circuits and control circuits for the inverter bridge 10 follow known technology which in this case controls the voltage across the capacitor 7 at a value which prevents conduction of diodes 8 and 9 while inversion is in progress, and responds to a call-for-regeneration signal. When regeneration is not required, the firing circuits for 10 are inhibited to de-activate this inverter.

CLAIMS

1. A regenerative converter for a switched reluctance drive having a thyristor bridge inverter so connected to an SR converter and to an ac source of voltage that no circulating currents between the diode bridge rectifier and the inverter are possible, and a second capacitor to which diodes of the SR inverter return energy, said second capacitor having its positive terminal connected to the positive terminal of the dc link capacitor via a diode whose conducting direction is chosen to convey current towards the positive terminal of the dc link capacitor and its negative terminal connected to the negative terminal of the dc link capacitor via a second diode whose conducting direction is chosen to convey current away from the negative terminal of the dc link capacitor.

Amendments to the claims
have been filed as follows

1. A regenerative ac to dc convertor for a switched reluctance motor, the convertor comprising: a rectifier having an ac input and a dc output arranged to derive a uni-directional voltage from the ac input; a first capacitor, having a positive terminal and a negative terminal, which capacitor is connected across the dc output of the rectifier to smooth the direct voltage output; an inverter, having ac terminals connected with the ac input of the rectifier and dc terminals; a second capacitor also having a positive terminal and a negative terminal, which second capacitor is connected across the dc terminals of the inverter; and diode means by which both of the positive terminals and both of the negative terminals of the first and second capacitors are respectively connected together, such that a voltage across the second capacitor can only exceed a voltage across the first capacitor by an amount sufficient to cause the diode means to conduct.

2. A convertor as claimed in claim 1 in which the diode means comprise a first diode, connected to conduct from the positive terminal of the second capacitor to the positive terminal of the first capacitor, and a second diode, connected to conduct from the negative terminal of the first capacitor to the negative terminal of the second capacitor.

3. A convertor as claimed in claim 1 or 2, including inductance means by which the dc terminals of the inverter are connected across the second capacitor.

4. A convertor as claimed in claim 3 in which the inductance means comprise first and second inductors each of which is respectively connected between the positive and negative terminals of the second capacitor and each of the dc terminals of the inverter.

5. A convertor as claimed in any of claims 1 to 4 in which the inverter consists of a thyristor bridge.

6. A convertor as claimed in claim 5 when dependent on claim 3 or 4 in which the inverter is a three-phase thyristor bridge, having two thyristors per phase serially connected with the inductance means across the second capacitor.

7. A convertor as claimed in any of claims 1 to 5 in which the rectifier is a bridge rectifier.

8. A convertor as claimed in claim 7 in which the rectifier is a three-phase bridge, having two serially connected diodes per phase.

9. A control system for a switched reluctance motor having one or more motor windings and being operable in a motoring or regenerative braking mode, the control system including a regenerative ac to dc convertor for a switched reluctance motor, the convertor comprising: a rectifier having an ac input and a dc output arranged to derive a uni-directional voltage from the ac input; a first capacitor, having a positive terminal and a negative terminal, which capacitor is connected across the dc output of the rectifier to smooth the direct voltage output; an inverter, having ac terminals connected with the ac input of the rectifier and dc

terminals; a second capacitor also having a positive terminal and a negative terminal, which second capacitor is connected across the dc terminals of the inverter; diode means by which both of the positive terminals and both of the negative terminals of the first and second capacitors are respectively connected together, such that a voltage across the second capacitor can only exceed a voltage across the first capacitor by an amount sufficient to cause the diode means to conduct; and switch means operable to control the current in the or each motor winding, the inverter being operable in the regenerative braking mode to inhibit circulating currents by drawing current from the second capacitor and partially discharging it until the diode means become non-conducting and being further operable to maintain the voltage across the second capacitor at a level at which the diode means remain non-conducting in the regenerative braking mode.

10. A regenerative ac to dc convertor for a switched reluctance motor substantially as specifically described herein with reference to Figure 3 of the drawings.

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Patents Act 1977
 Examiner's report to the Comptroller under
 Section 17 (The Search Report)

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Application number

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Relevant Technical fields

(i) UK Cl (Edition L) H2J (JCSR,JMLC,JSSS,JLRB)
 H2F (FDACS,FDACT,FDACX,FDAXS,
 FDAXT,FDAXX,FMAS,FMAT,FMAX)
 (ii) Int Cl (Edition 5) H02P 7/00, 8/00

Search Examiner

B J EDE

Databases (see over)

(i) UK Patent Office

(ii)

Date of Search

19 APRIL 1993

Documents considered relevant following a search in respect of claims 1

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
A	GB 2159672 A (GENERAL ELECTRIC CO)	1



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